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(54) IMPROVEMENTS RELATING TO STRUCTURAL MATERIALS

(71) We, BRITISH AIRCRAFT CORPORATION LIMITED, a British Company, of 100 Pall Mall, London, S.W.1., do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to laminated fibre reinforced plastics sheet materials. Such materials are well known. For example, it is known to form such a material from a minimum of three identical parallel fibred layers orientated such that their parallel fibres are spaced at equal angular increments of a maximum of 60° to each other. Such an arrangement provides a sheet material exhibiting similar stiffness characteristics in all directions in the plane of the material, that is to say, Young's Modulus for the material is substantially the same in all such directions. However, it is found that under certain bending load conditions such material tends to warp, or in other words twist, and hence it is necessary to so orientate the material when used in a structure that the material is not subjected to these conditions.

It is an object of the present invention to provide a laminated fibre reinforced plastics sheet material which can be incorporated in a structure without regard to its orientation in that structure.

According to the present invention a laminated fibre reinforced plastics sheet material is formed of identical parallel fibred plastics resin impregnated layers disposed in equal numbers on each side of a datum plane and bonded together by said resin, successive layers to each side of the datum plane being orientated such that their parallel fibres are set at equal angular increments to one another which are individually a maximum of 60° and which total 180°, the successive layers disposed on opposite sides of the datum plane and at equal spacings therefrom having the same angular setting.

By this arrangement, in which the layers are laid symmetrically on each side of the datum plane, the tendency of the material to warp under certain bend load conditions is substantially eliminated.

To provide extra thickness and hence extra stiffness a series of plies of the reinforced plastics sheets according to the invention may be formed one on top of the other. That is to say the plies are each formed by such a laminated sheet.

The fibres of the layers may be non woven or woven providing their major direction is substantially parallel and they may be of glass, carbon or boron for example.

Preferably the fibred layers or the series of plies are bonded between metallic facing sheets to complete the material.

A preferred embodiment according to the invention is described with reference to the accompanying diagram. This diagram is an exploded view of the material.

A datum plane 1 is shown by an area enclosed in broken outline. On each side of this datum plane are disposed three discrete layers or in other words, laminations 2, 3, 4 and 5, 6, 7, respectively, of carbon fibres impregnated with a thermosetting plastics resin. The carbon fibres are non-woven in this instance and lie in parallel warps. Those layers 2 and 5 which lie adjacent the datum plane 1 are disposed at the same angular setting. Those layers 3 and 6, which lie outwards of the layers 2 and 5, have their fibres orientated at 60° to those of the layers 2 and 5. Those layers 4 and 7, which lie outwards of the layers 3 and 6, have their fibres orientated at 60° to the layers 3 and 6 and hence at 120° to the layers 2 and 5. The angular spacing between the fibres of each successive layer on each side of the datum plane is 60°, the layers 4 and 7 being respectively at 60° to the layers 2 and 5.

Outwards of the fibre layers are two layers 8 and 9 of titanium. These layers in effect sandwich the fibre layers and help to prevent damage to them.

All the layers are bonded together in known manner by the application of heat and pressure.

By arranging the fibre layers as described,

a laminated fibre reinforced plastics sheet material is provided which has substantially similar stiffness characteristics in all directions of applied load in the plane of the sheet together with little or no tendency to warp or twist under certain bending load conditions. This enables the material to be utilised in a load bearing structure without the necessity for orientating it according to its load bearing abilities. Similarly it retains the advantages of multi-layer, multi-angle sheet material in that the fixing of the sheet material to adjacent structural members by bolts or similar anchorages is readily achieved. A disadvantage of materials having non-uniform stiffness characteristics is that since a hole for an anchorage is always adjacent an edge of the material a source of great weakness is provided if the material lying between the anchorage hole and the material edge is itself weak when subjected to loads which tend to draw an anchorage toward the material edge. This is exemplified by a uni-directional layer in which a load applied to an anchorage in the direction of the fibres subjects the resin bond alone to shear and causes adjacent fibres to tend to slide relatively to one another.

The described arrangement of six fibred layers yields a material with a minimum number of layers but of substantially constan stiffness in all directions in the plane of the sheet with little or no tendency to warp or twist. However there are alternative arrangements which give this result but with a greater number of layers. For example, five layers can be used on each side of the datum plane with their parallel fibres set at equal increments of 36°. With one layer set at 0°, the others in sequence are set at 36°, 72°, 108°, and 144°, respectively.

WHAT WE CLAIM IS:—

1. A laminated fibre reinforced plastics sheet material formed of identical parallel fibred plastics resin impregnated layers disposed in equal numbers on each side of a datum planc and bonded together by said resin, successive layers to each side of the datum plane being orientated such that their parallel fibres are set at equal angular increments to one another which are individually a maximum of 60° and which total 180°, the successive layers disposed on opposite sides of the datum plane and at equal spacings therefrom having the same angular setting.

2. A sheet material according to claim 1 having three layers disposed to each side of the datum plane with their parallel fibres set at angular increments of 60° to one another.

3. A sheet material according to claim 1 or claim 2 wherein the material of the fibres of the layers is carbon.

4. A sheet material according to any one of the previous claims in which the fibres and layers are bonded together by a thermosetting resin.

5. A sheet material according to any one of the previous claims wherein the fibre layers are sandwiched between two outer layers of a metallic material.

6. A sheet material according to claim 5 in which the metallic material is titanium.

7. A laminated fibre reinforced plastics sheet material substantially as herein described with reference to the accompanying drawings.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*